EXPERIMENTATION ON ANIMALS

AS A MEANS OF KNOWLEDGE

IN

Physiology, Pathology and Practical Medicine.

J. C. DALTON, M. D.

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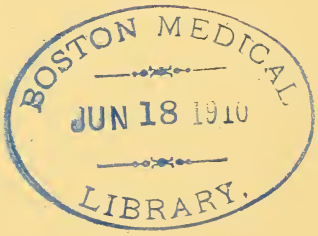

INTRODUCTION.

WITHIN the last ten years the method of investigation in the medical sciences, by means of experiments on animals, has been, on several occasions, the object of strenuous attacks on the ground of its inhumanity. The opponents of the practice also allege that it is needless for the acquisition of knowledge; that its results are generally unimportant; and that it is useless, or even deceptive, as a means of discovery and improvement. These allegations emanate from non-professional sources, and are made by men who are unacquainted both with the object of physiological experiments, the manner in which they are conducted, and the history of progress in the medical sciences. It is unnecessary to offer to the medical profession any defence of experimental investigations, since their value is notorious to all who are conversant with the subject. But the educated public, who have not turned their attention to medical matters, cannot be expected to know the facts of the case without some direct statement in regard to it. The recent attacks upon the method of experiment

have sometimes been made in extremely violent and denunciatory language, calculated rather to excite the feelings than to give any intelligent or impartial expression of the truth. It has even been declared, by one of the most active agitators in this field, that "even though these living dissections were productive of all that their advocates claim for them, mankind have no right to the knowledge thus acquired;" and demands have been made, from the same quarter, for legislation which should put a stop to "these wicked contributions to human knowledge, which mankind would be all the better off for never knowing."* It is evident, therefore, that the aggressive movement against experimental investigation is both unreasoning and persistent. It is liable at any time to resume its activity, and to endanger, both in the State of New York and elsewhere, the progress and improvement of physiological medicine. For these reasons it has been thought desirable to present in a condensed form the most important facts in regard to the character, the necessity, and the results of experimentation upon animals for scientific purposes, together with the testimony of the medical profession as to its value.

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* In the New York *Evening Post*, September 4th and 12th, 1874.

EXPERIMENTATION ON ANIMALS.

CHAPTER I.

ITS CHARACTER.

The charge of inhumanity, as brought against the practice of experimentation on animals, seems to ignore in great measure the motive and object of such investigations. Cruelty is the wanton destruction of life or infliction of pain, either for the gratification of a morbid ferocity, or for an unthinking amusement which disregards the suffering it may cause. Neither of these faults can be charged upon scientific investigation. Its object is solely the acquisition of a kind of knowledge which has been shown to be inferior to none in its importance for the welfare of mankind. It is also at the farthest possible remove from a careless or trifling occupation. Scientific knowledge is simply a knowledge which is definite and precise, which has been attained by known means, and which is capa-

ble of verification by repeated trials. It is a laborious pursuit, requiring care, industry, exactitude, and perseverance. It takes into account every condition under which an experiment is performed; and must do so, in order to derive from it any accurate results.

Experimenters are not, therefore, regardless of pain when it exists. Apart from the influence of the ordinary feelings of humanity, the character of their pursuit prevents their being regardless of anything connected with it. The existence and extent of sensibility in particular organs is sometimes itself an object of investigation; and one important piece of knowledge obtained in this way is that certain nerves are incapable of feeling pain, while others are highly endowed with this property.

The frequency and amount of pain actually inflicted in the course of physiological experiments have often been the subject of needless exaggeration. Those who are familiar with such investigations know that, in point of fact, the exhibition of pain in an experimental laboratory is an exceptional occurrence. As a

rule, all the cutting operations are performed under the influence of ether, and the animal is as completely unconscious of what is going on as the human patient while suffering an amputation. A visitor might frequent such a laboratory for a long time without hearing a cry or seeing a struggle, excepting such as are directly caused by the ether inhalation. This is because the infliction of pain is generally no part of the experimenter's object, and on every account it is preferable for him to avoid it.

In the few instances where the infliction of pain is a necessary part of the experiment, this pain is small in amount and momentary in duration. It would be an entire misapplication of terms to call it torture, or to apply to it the extravagant descriptions which have been sometimes employed. These are mostly cases in which the sensibility of a particular nerve or nervous centre is to be tested for a special purpose. In order to obtain the requisite information, it is simply necessary to apply so much irritation as will reveal the pre-

sence or absence of sensibility in the part; and when this is done the work is accomplished. A slight irritation, if it succeed, is all-sufficient; and if a more violent one be necessary, it is because the sensibility of the part is deficient, and, of course, the amount of suffering is diminished to a similar degree. The same thing is often necessary in the treatment of the human patient, in cases of paralysis, in order to determine whether and to what extent the power of sensibility is affected by the disease.

The infliction of pain, therefore, considering its objects, and the mode and extent of its application, does not bear the character of cruelty in physiological experiments. The destruction of animal life, for the same purpose, hardly requires a separate justification. It is a universal conviction that animal life is properly to be sacrificed whenever it may be necessary for the welfare of mankind. Nothing is more essential to this welfare, than the preservation of health and the relief or cure of disease. If we slaughter our cattle for their beef and hides, musk-deer for their perfume, the cochineal in-

sect for its carmine, and Spanish flies for the materials of a blister, there can be no doubt that any useful knowledge in medicine or surgery is abundantly worth the lives of the animals destroyed to obtain it.

CHAPTER II.

ITS NECESSITY.

The necessity for experimentation on living animals, in the medical sciences, rests upon a very simple reason. It is that these sciences have to do with the phenomena of life; and there is no way of learning what the vital phenomena are, except by examining them while life is going on. Experiments upon the living body are, for the physiologist, what experiments in chemistry are for the chemist, or those in electricity for the electrician. Abundant experience has demonstrated that in all these departments the only sure mode of obtaining information is by putting the question to nature, and receiving the answer from the same source. If we desire to know anything about the vital actions, it must be by investigation of the body during life. After death these actions have ceased, and cannot again be

put in operation. From dissection of the dead body we may learn the form and structure of the various organs; but their mode of action is not revealed in this way, and can only be discovered while the animal machine is still in motion.

The simplest example of this distinction is that of the different properties belonging to different nerves. There are two nerves distributed to the face, which are known respectively as the Fifth and the Seventh pair. These two nerves are precisely alike in their external appearance. Their dissection shows the same fibrous texture, and even when examined by the microscope they are seen to be made up of nervous filaments, having in both cases the same general form, size, and structure. No anatomist could discover, by examination of the dead body, any essential difference between them. But experiments conducted upon the living animal have shown that their physiological actions are distinct. The Fifth is a sensitive nerve, and endows the face with the power of sensation; the Seventh is a motor nerve, and

gives to the same part the power of movement.

The question has sometimes been asked, Why should physiologists desire a *repetition* of these experiments? Why perform an experiment of this nature over again, when it has already been once done and its effect ascertained? Is not this a needless, and therefore improper, infliction of pain or injury upon the animal employed?

This difficulty arises from a misconception of the object to be attained in extending a physiological or pathological inquiry beyond its original limits. An experiment, for example, which is performed to-day upon the circulation or the respiration, is not done to reiterate a previous discovery, but to investigate in a new direction, often equally important with the old one.

The Pneumogastric nerve, which, from its origin in the medulla oblongata, at the lower and back part of the brain, passes down the neck and sends branches to the larynx, the lungs, and the stomach, has been long the subject of investigation. This is one of the nerves

which possess little or no sensibility to pain, but it yet has an important influence on the animal functions. Galen, by dividing the pneumogastric and its laryngeal branch, discovered that it was essential to the production of the voice. Modern experimenters have found that its division upon both sides, in the living animal, is followed by a diminished rapidity in the movements of respiration. The breathing becomes slower and slower, and at last the animal dies without exhibiting any other very marked symptom than this gradual suppression of the movements of respiration. The conclusion derived from these and other similar results is, that the involuntary act of breathing, in health, is mainly excited by some stimulus conveyed through the pneumogastric nerve from the lungs to the medulla oblongata, in which it originates. So far, the experiments have done their work. This knowledge is acquired; and it is not necessary to divide the pneumogastric nerves again, to discover what has already been ascertained.

There is, however, a disease affecting the

human subject, insidious in its origin and fatal in its result, which has long baffled the efforts of the physician for its cure. It is known as Diabetes; and its most prominent character, by which it is distinguished from other affections, is the unnatural existence of sugar in the urine. This sugar pre-exists in the blood of patients suffering from diabetes. It is drained away from the system by means of the kidneys, and its continuance in the product of these organs is accompanied by progressive wasting of the patient's flesh and strength. This is practically all that is known of diabetes. As yet, no curative remedy for this affection has been discovered; and when once established, it generally follows a regular and certain course of emaciation, debility, and death.

But physicians, nevertheless, have a more or less distinct belief that diabetes may be a curable disease. If, as they say, we only knew its cause, if we understood the mode of its production, we should then get at the source of this disturbance in the nutrition of the body, and perhaps we could then do something to cure or

to prevent it. Now, experimenters are making sure and steady progress in this direction.

About twenty-five years ago, M. Claude Bernard, Professor of Physiological Medicine at the College of France, made the discovery, by means of experiments upon animals, that sugar is a natural ingredient of the healthy liver. It is produced in small quantity in the tissues of the organ, is rapidly absorbed and carried away by the blood, and is almost immediately decomposed or transformed in the circulation. If, however, a larger quantity of the same kind of sugar be injected into the blood-vessels of a healthy animal, the surplus at once begins to be discharged by the kidneys, and continues to appear in the urine, until it has been completely eliminated from the system.

Some years afterward, Bernard also made the remarkable discovery that if, in the living animal, a small puncture be made in the medulla oblongata, at the point of origin of the pneumogastric nerves, a condition of diabetes is produced at the end of one or two hours. The blood becomes loaded with an unnatural

proportion of sugar, which is consequently discharged by the urine. This condition lasts for a certain time, until the immediate effect of the puncture has passed away, when it disappears, and, if no other injury have been inflicted, the animal returns to a state of health.

The next question of importance is, By what mechanism does this puncture produce diabetes? Does it increase the production of sugar in the liver, or does it interfere with its decomposition in the lungs? Either of these causes might produce its accumulation in the blood, and therefore its discharge by the kidneys. Now, if the puncture of the medulla act directly in this instance by an irritation conveyed through the pneumogastric nerve, then, if the nerve be previously divided, the puncture of the medulla ought no longer to produce diabetes. Thus an occasion arises for a repetition of the experiment of dividing the pneumogastric nerve, but with an entirely different object. This experiment has been done; and it has been found that, notwithstanding the previous division of the pneumogastric nerve, puncture

of the medulla oblongata is still followed by a state of temporary diabetes. In this way another step has been made toward unravelling the pathology of an obscure disease. If these investigations go on, the time will certainly come when we shall know what is the nature and mode of origin of diabetes. If they are abandoned, we shall never know it.

CHAPTER III.

ITS RESULTS.

The information which has been acquired by the experimental method is so extensive, that without it medical science could never have reached its present position. The history of medicine shows that every important discovery in physiology has been directly due to its employment, and that the more modern advances in pathology, as well as many of those in practical medicine and surgery, have only been made possible through the same means. The most remarkable instances of its utility in this respect are the following:

I. *The Circulation of the Blood.*—Everything that we know in regard to the circulation of the blood has been learned by means of experiments on living animals. Previously to the time of Galen, the veins were the only vessels supposed to contain blood; the arteries

being considered as air-tubes, destined to convey the air taken in by respiration throughout the system. This was because, in examining the dead body, the veins are actually seen to contain blood; while the elastic arteries, which have nearly emptied themselves after the stoppage of the circulation, admit the air to their interior when cut across, and resume their open cylindrical form. Consequently in the dead body, when dissected, the two sets of vessels really differ in this respect, the veins containing blood and the arteries containing air. When an artery was wounded during life, and discharged blood, it was thought that it first emptied itself of the air with which it had been previously filled, and that the blood then passed into it from distant parts.

But Galen, about the year 150,* experimented by exposing an artery in the living animal, and including a portion of it between two ligatures, so as to prevent any access of the blood from distant regions. He then made an

* Galeni Opera. An in Arteriis Natura Sanguis contineatur, Cap. vi.

opening in the vessel between the ligatures, and showed that no air escaped from it, but only blood. Consequently it must have contained blood beforehand. From that time it was known that both sets of vessels—arteries as well as veins—were blood-vessels; and that two kinds of blood—arterial and venous—were contained during life in the vascular system.

These two kinds of blood, however, were still thought to be both distributed from the central parts of the body outward, the arterial and venous currents moving in the same direction; the venous blood supplying the grosser materials of nutrition, the arterial blood supplying the tissues with a more active and vital stimulus.

Nearly fifteen centuries afterward, Harvey discovered, by experiments on the living animal, that the two currents run in opposite directions; that the arterial blood passes from within outward, and then returns, as venous blood, from without inward. This constitutes his discovery of the *circulation* of the blood; or, as he expresses it, the "motion of the

blood, as it were, in a circle." * This important fact, which lies at the foundation of all our knowledge as to the physiology, the diseases, and the treatment of the vascular system, forms the principal acquisition for which Harvey's name is known; but in the course of the same investigations he made other discoveries of nearly equal value, which were preliminary to that of the circulation. Such was the true action of the heart, which he first showed, by direct inspection, to be an organ of impulsion, propelling the blood by its muscular contractions through the distensible and elastic arterial tubes; the expansion of the arteries being caused by the impulse of the blood forced into them from the heart. This was the first demonstration of the real nature of the arterial *pulse*, upon which physicians constantly rely for their guidance, in the examination and treatment of disease.

II. *Respiration.*—The Hon. Robert Boyle,

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* Harvey's Works. Sydenham Edition. London, 1847, p. 46.

in 1670,* experimented upon cats, birds, frogs, fish, snakes, and insects, by enclosing them in the receiver of an air-pump, which was then a recent invention. He thus showed by exact methods that the atmospheric air is necessary to the maintenance of life; and that even when this air is present, in a limited space, it becomes vitiated by continued respiration. In order to maintain life, accordingly, the vitiated air must be removed and replaced by a fresh supply.

Mayow,† by experiments published in 1668 and 1674, proved that in the respiration of mice the air was not only vitiated, but also diminished in volume by about seven per cent. He concluded that something in the air was consumed or used up by respiration; and he gave to this unknown substance the name of "nitro-aereal spirits," because he believed it to be the spirituous or gaseous element of nitre, and also a part of the atmospheric air.

* Philosophical Transactions. Vol. v., p. 2011, 2035.

† Milne-Edwards. Leçons sur la Physiologie. Paris, 1857. Tome i., p. 388.

About one hundred years later Priestley* resumed the experiments on air vitiated by respiration, in order to ascertain how it might be regenerated and again made capable of supporting life. He first caused the air to be thoroughly deteriorated by the respiration of mice; after which he subjected it to a great variety of processes, and again tested it by the introduction of other mice. He tried in this way the effect of long keeping, a high temperature, rarefaction, condensation, and contact with vegetable mould; all without success. Finally, he found that by enclosing in it green and growing plants, the vitiated air became regenerated and again fit for the respiration of animals. He thus established the complementary relation of animal and vegetable life; namely, that animals, by breathing, deprive the atmosphere of a certain property which is restored to it by vegetation.

But the most important advance in this direction was made a few years afterward

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* Philosophical Transactions. Vol. lxii., p. 147.

by Lavoisier,* when he discovered that respiration consists in the absorption of oxygen and the exhalation of carbonic acid. By experimenting with sparrows, in air which had been deoxidized by the calcination of mercury, he found that they could no longer breathe in it. He concluded that the respirable portion of the air had combined with the mercury; and by reducing this substance again to the metallic state, collecting the gas evolved in the operation, and adding it to the non-respirable residue, he found that the mixture had again become respirable, and that the animals no longer died in it. He further proved that when air was vitiated by continued respiration, it not only lost its respirable portion, or oxygen, but it also contained another gas, or carbonic acid, which would unite with lime-water to produce carbonate of lime.

In this manner were developed the two main features in the process of respiration.

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* *Expériences sur la Respiration des Animaux.* Mémoires de l'Académie des Sciences. Paris, 1777.

Many other details have since been added, relating to the time, place, quantity, and manner of the absorption and discharge of these two gases. But the principal facts were established at that time; and our real knowledge of the function of respiration dates from Lavoisier, as that of the circulation dates from Harvey.

III. *Artificial Respiration.*—The first attempt at continuing life indefinitely by this means was made by Robert Hook in 1664,* in the course of some experiments upon dogs, in which he showed that by alternately inflating the lungs of the animal with bellows, and allowing them to collapse, the movements of the heart might be kept up for a long time. In order to determine whether this effect were caused merely by the physical movement of the parts, or by some chemical influence of the air in the lungs, he repeated the experiment by attaching a second pair of bellows to the first; working it very rapidly, so as to keep

* Philosophical Transactions. Vol. ii., p. 539.

the first pair "always full and always blowing into the lungs." Numerous incisions were at the same time made over the surface of the lungs, to allow of the escape of the air thus forced into them. By this method the lungs were kept motionless, but with a current of air steadily passing through them. As this experiment had the same results with the former, it was shown :—

First, That life might be indefinitely prolonged, under certain circumstances, by the alternate inflation and collapse of the lungs, in artificial respiration ; and,

Second, That this was effected, not by the simple movement of the parts, but by the continued passage of air through the pulmonary channels.

Artificial respiration has since been employed, both for studying the action of the heart and vessels, and for resuscitating asphyxiated animals. It was finally applied to the human subject, and is now a recognized means of preserving life in cases of drowning, hanging, asphyxia from breathing noxious gases,

and the suspended animation of the newly born.

IV. *The Transfusion of Blood.*—The earliest form in which the idea of transfusion presented itself was that of injecting into the blood-vessels certain medicinal agents. This was first done about the middle of the seventeenth century, under the auspices of Robert Boyle;* at which time it was shown that a solution of opium might be thrown into the veins of a dog, so as to narcotize the animal without killing him. This discovery was followed by the experiments of Richard Lower † on the transfusion of blood from the vessels of one animal into those of another. These experiments were highly successful, and first showed that death from hemorrhage might be prevented by the transfusion of blood. The results attained soon led to the idea of performing the same operation upon the human subject; but this was not carried out with

* Philosophical Transactions. Vol. i., p. 128.

† Philosophical Transactions. Vol. i., p. 353.

success until after the investigations of Dr. James Blundell* had thrown further light upon the subject. Dr. Blundell performed thirty-three experiments on animals, and showed by them:

First, That dogs exhausted by repeated hemorrhage may be resuscitated, even after the stoppage of respiration, by injecting the blood of other dogs.

Second, That the transfusion of blood, in animals of the same species, may be successful, whether the blood used be arterial or venous.

Third, That the blood may be received into a cup, and passed through a syringe, without being thereby rendered unfit for the purposes of life.

The transfusion of blood, thus placed upon a sound footing, and still further improved by subsequent investigations, was adopted by the profession, and has become an established and

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* Researches, Physiological and Pathological. London, 1824.

useful operation, to obviate the effects of exhausting hemorrhage. No less than fourteen cases in which life was saved by this means have been recorded by a single writer.*

V. *Digestion.*—After the digestive process had been studied with partial success by Reaumur and Spallanzani during the last century, the first decisive results were obtained by Dr. Beaumont,† in 1825, in the well-known case of Alexis St. Martin. Dr. Beaumont utilized for this purpose a permanent opening in the coats of the stomach of this patient, resulting from an accidental gunshot wound; and showed by his experiments and observations that the stomach secretes a peculiar acid fluid—the gastric juice—which has the property of dissolving the ingredients of the food. The value of these results afterward suggested the idea of making a similar permanent opening

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* Bérard. Cours de Physiologie. Paris, 1852. Tome iii., p. 219.

† Experiments and Observations upon the Gastric Juice. Boston, 1834.

upon the lower animals, which was first done in 1842, and has been frequently repeated since;—and in consequence of these experiments the most important information has been acquired in regard to the secretion, ingredients, and mode of action of the gastric juice. Similar operations have been also performed for the purpose of obtaining the other internal secretions, such as the bile, the pancreatic and intestinal juices, or of learning the effect which they exert upon the food and upon each other in the digestive canal. The experiments, so conducted, have confirmed in the main those performed by Dr. Beaumont, and have greatly increased in many respects the extent and precision of their results.

VI. *The Nervous System.*—This department of medicine is now so extensive, both in its physiology and its pathology, that few subjects can be said to have received greater attention. Galen, who, so far as we know, was the first experimental physiologist, demonstrated many important facts in regard to it. He showed that the spinal cord is the path

through which the impulse for voluntary motion passes, in its course from the brain to the muscles of the body and limbs; for if it be divided at various points in the neck and back, a paralysis is produced which affects only those muscles situated below the level of the injury.* He also pointed out the different effects produced upon respiration by dividing the intercostal nerves, which animate the muscles of the chest, and the phrenic nerve, which belongs to the diaphragm. All these facts are of the first importance in enabling the physician to determine the seat of a nervous injury, through the symptoms afforded by local paralysis or the movements of respiration. Galen ascertained, furthermore, by similar means, that the voluntary impulses for motion pass through the right and left lateral halves of the spinal cord, for the corresponding sides of the body; and he studied the pneumogastric nerve so far as to

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* Galeni Opera. De Administrationibus anatomicis. Liber viii., Cap. viii., ix.

learn that, through the branches which it sends to the larynx, it presides over the formation of the voice.

The progress of modern discovery in regard to the nervous system began in the early part of the present century, when Sir Charles Bell,* by experiments upon the ass, dog, and monkey, found that the facial nerve, or seventh pair, was not a nerve of sensibility, but a nerve of motion; and that the power of sensation in the face was due exclusively to the fifth pair. This discovery at once led to important results in practice. Before that time, surgeons had been in the habit of cutting the seventh nerve for the cure of tic-douloureux,—of course without success; since the operation not only failed to relieve the neuralgia, but also produced a temporary paralysis of motion on the corresponding side of the face. This is a marked instance of the superiority in precision of knowledge derived from experiments, over that for which we

* Philosophical Transactions of the Royal Society, for the year 1821. London, 1821, p. 398.

are often dependent upon the observation of disease. Sir Charles Bell himself says that previously to 1821, as the result of surgical operations upon the face for tic-douloureux, "after fifty years of such experience we remained quite ignorant of the distinctions in these nerves." * But since his discovery, a surgeon would never think of repeating this mistake.

In 1822, Magendie,† by experiments upon young pups, discovered that the anterior and posterior roots of the nerves emerging from the spinal cord have distinct functions; the anterior roots being the channels for motion, the posterior for sensation. This discovery, which has been most fruitful in its influence, is regarded as fundamental in the modern physiology and pathology of the nervous system. It is not only of importance in itself, but has put other observers upon the track of many varied acquisitions. All the information which we now pos-

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* Nervous System of the Human Body. Third edition. London, 1844, p. 77.

† Journal de Physiologie. Paris, 1825. Tome ii., p. 276.

sess in regard to recurrent sensibility, reflex action, the regeneration of divided or injured nerves, the nervous mechanism of respiration, and the functions of the different nervous centres, has been obtained by experiments and investigations conducted more or less under the influence of the discovery made by Magendie.

VII. *The Hunterian Operation for Aneurism.*—Before the year 1785 the best treatment known for aneurismal disease of an artery was that of opening the aneurism and tying the vessel in the wound, or applying a ligature immediately above and below the affected part. This operation, however, was frequently unsuccessful, owing to fatal attacks of secondary bleeding from the aneurismal tumor or from the ligatured part of the vessel. To avoid these bad results, John Hunter introduced the operation which consists in applying a ligature to the artery at a considerable distance from the tumor, where its coats are in a healthy condition. But before attempting this in the human subject, it was necessary to see whether such an operation could be performed upon a healthy

artery without danger. He accordingly* laid bare the inner coat of an artery in the dog, by dissecting off the two outer layers until he saw the blood through the remaining membrane. The wound was then closed; and when the animal was killed, three weeks afterward, the parts were found to have healed, the canal of the artery not having been injured. A simple exposure of the vessel having thus been shown to be unattended with danger, the operation was repeated upon another animal, with the addition of keeping the wound open for a time by the insertion of a piece of lint. As this also was unattended by any dangerous symptoms, Mr. Hunter concluded that the ulceration and bleeding which had followed the former operations for aneurism were due more to the locally diseased condition of the vessel than to the necessary dissections; and that if he placed his ligature higher up, upon a healthy portion of the artery, he might have better success

* The Works of John Hunter. London, 1835. Vol. iii., p. 597.

than that which had followed the older practice.

These expectations were confirmed by experience; and the Hunterian operation has since been the means of saving many lives and preserving many limbs which must have been sacrificed without it.

VIII. *The Regeneration of Bone from the Periosteum.*—There are few improvements in surgery which have been more beneficial than that derived from this discovery. When a large portion of any bone requires to be removed on account of fracture or disease, the permanent deficiency of the bony parts, after the healing of the wound, is a very serious inconvenience; so much so, that surgeons formerly were often in the habit of amputating the entire limb rather than retain a member which would be an incumbrance to the patient instead of an advantage. The study of the mode of reparation of bone, by means of the periosteum, has shown how this difficulty may be avoided, and how much advantage may be gained in the preservation of injured or diseased parts.

Du Hamel, in 1740,* and Hunter, in 1772,† first learned, by experiments on pigeons, fowls, and young pigs, that the natural growth of bone takes place mainly from the exterior, where it is in contact with its fibrous covering, or periosteum. In 1837, Mr. Syme,‡ by experiments on the dog, found that if a considerable portion of the bone of a limb, with its periosteum, were cut away, no bony union took place, and the limb was permanently useless; but if the same quantity of bone were removed, its periosteum being left in place, bony tissue was reproduced and a solid union of the parts effected. In 1858, Ollier § carried still farther the investigations on this subject, by practising resections and extirpations of the long bones in dogs and rabbits,

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* Mémoires de l'Académie Royale des Sciences. Paris, 1741, '42, and '43.

† The Works of John Hunter. London, 1835. Vol. iv., p. 315.

‡ Transactions of the Royal Society of Edinburgh. Vol. xiv., p. 158.

§ Journal de la Physiologie de l'Homme et des Animaux. Paris, Janvier, 1859.

varying the mode of operation, for the purpose of ascertaining the extent to which the regenerative power of the periosteum might be effectual.

The practical importance of these results, for patients suffering with disease or injury of the bones, has been fully appreciated by surgical practitioners at the present day. Formerly a shattered or diseased bone was taken away altogether with its periosteum, leaving a false joint, or the limb was amputated. Now the periosteum is left, and new bone is formed to take the place of the old one.

IX. *Action of the Rattlesnake Venom, and the Treatment of Venomous Wounds.*—Many popular remedies have been proposed for the treatment of rattlesnake wounds, but their efficacy has always been uncertain, and even the tests which might be applied to determine their value were very indefinite and gave but little information. The venom of the rattlesnake is often so rapid and severe in its operation, and at other times so deficient in activity, its effects vary so much with the size and species of the animal wounded, and even with

the circumstances under which the wound is inflicted, that fifteen years ago we may be said to have known practically nothing about it, excepting its danger and the painful death sometimes caused by its action.

In 1860, Dr. Weir Mitchell * investigated this subject by keeping, for many months, several living rattlesnakes constantly under his observation, studying their habits and physiological peculiarities from every point of view. He thus learned the mode of secretion of the venom, the mechanism of its ejection and introduction into a wound, the circumstances which may favor or prevent its inoculation, and lastly, the symptoms which it produces in different kinds of animals when no remedy is applied. He was thus in a position to appreciate the real effect of remedies when administered in other cases. He performed seventy-

* Smithsonian Contributions to Knowledge. Researches on the Venom of the Rattlesnake, by S. Weir Mitchell, M.D., Washington, 1861; and an article on the Treatment of Rattlesnake bites, in the North American Medico-Chirurgical Review. Philadelphia, vol. v., p. 270.

three experiments on frogs, serpents, birds, dogs, and rabbits, and reached in this way, the only conclusions of any worth now in our possession in regard to the matter; namely, the usefulness of the intermittent ligature, and the proper method of administering stimulus to counteract the effects of the venom.

X. *The Origin of Parasitic Diseases.*— There are certain animal parasites liable to infest the human body, some of which are exceedingly troublesome, others often fatal. When once introduced into the system they are very difficult to dislodge, and the more dangerous of them are almost unamenable to treatment. But their entrance into the body can be easily avoided by exercising proper care, if we only know from what source they come. This is an instance in which the *prevention* of a disease is much more important than its cure. Another reason why prevention is particularly valuable in parasitic diseases, is that many of these affections are liable to become suddenly epidemic; many persons being

contaminated at once from a single cause. On every account, therefore, it is especially the *origin* of a parasitic malady, which it is of consequence for us to know.

One of these parasitic intruders is the Tapeworm. We are now aware that it is derived from eating pork which is infested with another parasite, namely, cysticercus. But the cysticercus is so different from the tapeworm in size, structure, and appearance, that no connection was formerly supposed to exist between them. The identity of the two was discovered in Germany about the year 1845–50, by Siebold and Küchenmeister.* By experimenting upon mice, rabbits, dogs, and cats, these naturalists found that certain species of cysticercus and tapeworm were specifically identical; and that a cysticercus in the flesh of one animal, when eaten by another, became developed into a tapeworm in the intestine of

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* Transactions of the Silesian Association for National Instruction, Scientific Department; Session of July 7th, 1852.

the second. This discovery soon led to the additional result that tapeworm in man is derived from the cysticercus of the pig; and showed in what way infection by this parasite may be avoided.

A more striking instance is that of the parasite called Trichina spiralis. This worm has been known since 1832 as infesting the muscles of the human subject, where it was some times found, after death, in large numbers. But in these cases there was no evidence of the patient having suffered anything from the presence of the worms; and, notwithstanding their great abundance, it was the universal opinion that trichina spiralis was a quiescent and harmless parasite in the human muscle. Nothing was known of its origin or mode of development.

But about the year 1855, certain physiologists began to experiment with these parasites; and, by administering flesh infected with trichina to pigs, dogs, and rabbits, they found that the worm became further developed in the intestine of these animals. In 1859, Professor

Leuckart,* in Giessen, continued the investigation, showing that in the intestine of the second animal the growth of the trichina reached its completion; a perfect sexual organization being developed, with the production of young in great numbers. The muscles of the second animal thus became infested with the progeny of the trichina which had been swallowed in an embryonic condition with the food.

This was the state of our knowledge when, in the year 1860, the members of a family in Dresden were taken ill with syptoms of intestinal irritation, fever, and general pains. One of them, a servant-girl, died, and on examination after death the muscles were found to be full of trichina spiralis. Some of these parasites were administered to a healthy rabbit, which died at the end of a month, and was then found to be infected with trichina. A little of the flesh of this animal was given to a second rabbit, which also died four or five weeks later; and a portion of its flesh, administered to a third

* Untersuchungen über Trichina spiralis. Leipzig, 1860.

animal, produced death after a similar interval, and in the same way. In the meantime, a part of the pork, which had served as the last meal of the family before their illness, was traced and examined, and found to contain trichina.

By these investigations, the medical profession became aware of the existence of a fatal and heretofore unknown disease, and at the same time were made acquainted with its source and the manner of its production. Undoubtedly many cases of trichinosis had happened before 1860; but they were not understood, and the patient was supposed to be laboring under some form of fever or rheumatism. We now know the origin of the malady, and can guard against it; and furthermore, by similar experiments,* the important facts have been shown that meat infected by trichina is not rendered harmless by smoking or pickling, but only by a thorough cooking throughout its substance.

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* Pagenstecher, Die Trichinen. Leipzig, 1865, p. 49.

For the last five years very active researches have also been going on in regard to the origin and communication of certain contagious and infectious diseases, in which microscopic vegetable parasites are the means of transmission. They have been conducted with the aid of inoculation and other experiments on animals, by Professors Coze and Feltz, formerly of the University of Strasbourg; by M. Davaine, of the French Society of Biology; by Professor Vulpian, of the Faculty of Medicine at Paris; by Professor Burdon-Sanderson, of University College, London; by Professor Eberth, of Zürich, and by Drs. Oertel and Frisch, of Vienna. The possibility of preventing these diseases in particular cases, and of adopting effective hygienic measures for the protection of the public at large, depends directly upon the knowledge possessed by the medical profession as to the nature and mode of propagation of the infectious agent.

CHAPTER IV.

RESOLUTIONS OF MEDICAL SOCIETIES.

From the Proceedings of the MEDICAL SOCIETY OF THE STATE OF NEW YORK, *at its annual meeting, February 7th*, 1867.

Dr. Crandall, from the Committee appointed to prepare and report a memorial to the Legislature, in regard to the proposed interference with physiological investigation by means of experiments on animals, made the following report, which was accepted and adopted:

To the Honorable the Legislature of the State of New York.

The members of the Medical Society of the State of New York, now assembled at their annual meeting, in the City of Albany, respectfully represent to your honorable body:

That they are informed that a bill has been, or is to be, presented for your consideration at the present session, to make more stringent the Act for the Prevention of Cruelty to Animals, and that this bill is intended or calculated, among other things, to interfere with or prohibit experiments upon animals for physiological and medical purposes, on the ground that

such experiments are barbarous and cruel, and at the same time useless or unnecessary for the interests of humanity. . . . . Your memorialists would, therefore, respectfully represent, for the reasons given above, that physiological experiments upon animals are necessary, proper, and valuable for the due cultivation and improvement of the medical art; that they may be, and in point of fact are, performed without the wanton infliction of suffering or cruelty; that they lead to results which are of benefit, both to mankind and the animal creation, in the prevention and alleviation of disease; and that it would be injurious to the interests of science and humanity to deprive the medical art of the assistance which they afford.

Resolved, That the above memorial be adopted by the Society, and that the President of the Society be instructed to transmit a copy of it, with a copy of this resolution, to the two branches of the Legislature, and to the Governor of the State of New York.

C. M. CRANDALL, WILLARD PARKER,
S. O. VANDERPOEL.

Preamble and Resolutions adopted by the MEDICAL SOCIETY OF THE COUNTY OF NEW YORK, *at the Meeting held September 28th,* 1874.

Whereas, It is believed that a movement has been inaugurated having for its object to abrogate or practically nullify the clause in the present law for the prevention of cruelty to animals, which declares that "*Nothing in this act shall be construed to prohibit or interfere with any properly conducted scientific experiments or investigations;*" therefore,

Resolved, I. That in the opinion of this Society, investigations in physiology and pathology, by means of experiments on animals, are and have been the most fruitful source of increased knowledge with regard to the causes of disease and its means of prevention and cure;

II. That these experiments and investigations are habitually carried on by medical men without cruelty, nearly always without suffering to the animals employed, and never with any wanton infliction of pain or distress;

III. That authoritative interference, inspection, or control of these investigations, by per-

sons unacquainted with their methods and objects, would necessarily defeat their aims and practically prevent their performance;

IV. That the suppression of experimental investigations of this nature would arrest the progress of physiological science, would obstruct the acquisition of knowledge in regard to the causes of disease, and would be accordingly a disaster to the profession of medicine and to the welfare of mankind.

Also *Resolved*, That for these reasons the members of this Society earnestly hope that the legal provision now existing, which recognizes the importance and value of such investigations, will be continued in full force and effect.

Unanimously adopted.

ELLSWORTH ELIOT, M.D., *Pres.*
A. E. M. PURDY, M.D., *Sec.*

The foregoing Preamble and Resolutions were also adopted by the

NEW YORK ACADEMY OF MEDICINE,
at the Meeting held November 5th, 1874.

AUSTIN FLINT, M.D., *Pres.*
W. T. WHITE, M.D., *Sec.*

Preamble and Resolutions adopted unanimously by THE MEDICAL SOCIETY OF THE COUNTY OF WESTCHESTER, *at the Meeting held October 20th*, 1874.

Whereas, The Medical Society of the County of Westchester, in common with the profession of the State, recognizing the benefits which have accrued from judicious experimentation upon the lower animals in the interest of science and humanity; and

Whereas, It is believed an effort is to be made before the next Legislature to repeal or alter that portion of the existing laws of this State which permits "*any properly conducted scientific experiments or investigations;*" therefore

RESOLVED, That this Society believes that the repealing or alteration of said laws, so as to interrupt in any way the present existing facilities for scientific investigation, will result in arresting the progress of discovery of the phenomena of life, and the causes and prevention of disease.

Resolved, That in no department of physical science has greater progress been made than in Physiology and Pathology, and that no discoveries have conferred greater blessings on mankind than those embraced within their domain, exemplified in the brilliant discoveries of Harvey, Ambrose Paré, and Jenner, the many illustrious savans of the continent and our own country, which have been made and established through the important and indispensable aid of vivisection of the lower animals. That such investigations are conducted without unnecessary pain or wanton cruelty, and usually with the aid of anæsthetics.

Resolved, That the members of this Society, duly appreciating and honoring the wisdom of the framers of our existing laws relating to this important subject, earnestly desire that they may continue unchanged, that the progress of research and discovery, which has hitherto distinguished our State, may not be interrupted.

Wm. H. Helm, M.D., *Pres.*

J. Francis Chapman, M.D., *Sec.*

Preamble and Resolutions unanimously adopted by the
RICHMOND COUNTY MEDICAL SOCIETY,
at the Meeting held November 4th, 1874.

Whereas, It is understood that a well-intended but ignorantly conceived movement is on foot, to expunge from the existing act for the prevention of cruelty to animals the clause excepting "*properly conducted scientific experiments or investigations;*" therefore

Resolved, That this Society, distinctly affirming that such experiments are habitually conducted without cruelty, and whenever possible without the infliction of pain upon the animals employed, does most earnestly protest against any legislative action prohibiting or limiting a method of investigation on which chiefly must depend in the future, as in the past, the advancement of physiological, pathological, and

therapeutical knowledge, and which is therefore of direct and essential importance for the welfare of mankind.

C. Henry King, M.D., *Pres.*

Frank Anderson, M.D., *Sec.*

Preamble and Resolutions adopted by the NEW YORK PATHOLOGICAL SOCIETY, *at the Meeting held November* 11th, 1874.

Whereas, Certain publications have recently been brought to the notice of this Society, having for their object to excite a prejudice against the propriety and utility of experiments upon living animals, as performed for the purpose of medical investigation, and to control or prohibit such experiments by legal enactment; and

Whereas, The members of this Society have abundant reason to know that the method of experimentation upon animals has been productive of many useful discoveries in pathology, as well as in physiology and practical medicine; therefore

Resolved, I. That experimentation upon animals is of the same value for investigation and discovery in medicine as experiments in physics and chemistry for the corresponding branches of natural science;

II. That this method of investigation, by in-

creasing our knowledge of the causes and consequences of disease, leads to enlarged facilities for its prevention and cure, and has thus been the means, in many instances, of preserving human life and relieving human suffering;

III. That, in the opinion of this Society, it would be in the highest degree impolitic and unjust to prohibit experimental investigations of this nature, or to withdraw from them the protection and recognition which is wisely afforded by the law.

Unanimously adopted.

H. KNAPP, M.D., *Pres.*

GEO. F. SHRADY, M.D., *Sec.*

Preamble and Resolutions unanimously adopted by the

SOCIETY OF NEUROLOGY AND ELECTROLOGY,

New York, November 16th, 1874.

Whereas, The propriety of physiological and pathological investigations by means of experiments upon animals has been recently called in question by the presiding officer of the Society for the Prevention of Cruelty to Animals, on the alleged ground that such investigations are cruel, unnecessary, and valueless; therefore

Resolved, That, in the opinion of this Society, the results which have been derived from experiments upon animals constitute a large part of the knowledge at present existing in regard to physiology, pathology, and therapeutics;

That without such investigations, many of the most valuable facts heretofore discovered, as to the healthy functions of the living body and the causes and cure of disease, would necessarily have remained unknown; and

That to discontinue experimentation upon

animals, by legal interference or prohibition, would deprive the Medical Profession of one of the surest means now at their disposal for further improvement in the prevention and cure of disease, and the relief of human suffering.

Resolved, That the clause in the present law which exempts scientific investigation from the charge of cruelty, and protects it, as necessary and valuable for the welfare of mankind, was adopted by the Legislature of the State of New York, in the Session of 1867, after full and deliberate consideration; that it is a wise, just, and humane legal provision, and that the members of this Society earnestly desire that it should remain unchanged.

MEREDITH CLYMER, M.D., *Pres.*

ALFRED L. CARROLL, M.D., *Sec.*

Resolutions adopted unanimously by the MEDICAL SOCIETY OF KING'S COUNTY, *at the Meeting held November 17th*, 1874.

Resolved, That this Society learns with regret that it is seriously proposed to so change the laws of the State as to circumscribe or abolish the practice of vivisection.

Resolved, That such experimentation upon the lower animals is a most important source of knowledge and usefulness to the medical profession and indirectly of great benefit to the community at large, and that, as a rule, it is humanely conducted.

Resolved, That this unwise and retrogressive change, sought in the laws, should be opposed on the ground of humanity, and also because, this essentially important practice being in vogue in all intelligent sections of the civilized world, its abolition in this State would

place our immediate community and its institutions at a disadvantage when compared with others wherein the law will not and cannot be used against it.

ALEX. J. C. SKENE, M.D., *Pres.*
R. M. WYCKOFF, M.D., *Sec.*

Preamble and Resolutions adopted by the NEW YORK NEUROLOGICAL SOCIETY, *at the Meeting held December 7th*, 1874.

Whereas, A discussion has recently emanated from the Society for the Prevention of Cruelty to Animals, in which the practice of experimentation upon animals for scientific purposes is charged with cruelty, and asserted to be unnecessary and without beneficial results; therefore,

Resolved, That the above charges could only have been made in ignorance of the facts universally known to the Medical Profession; namely, that experimentation upon animals has been the principal source of all definite knowledge in Physiology,—has thrown light upon obscure and important points of Pathology,—and has led to many valuable results in the medical and surgical treatment of disease; also,

Resolved, That any legislation prohibiting the continuance of scientific investigation by this means, or subjecting its pursuit by

medical men to the control of non-medical inspectors, would have the effect to interdict in great measure future progress and improvement in the science and art of medicine; and would be, for the State in which it should be enacted, a professional calamity and disgrace.

Resolved, That the members of this Society hope and believe that no such proposed enactment would receive the countenance of the Legislature of the State of New York.

Unanimously adopted.

WILLIAM A. HAMMOND, M.D.,
President.

G. W. WELLS, M.D., *Secretary.*

CHAPTER V.

TESTIMONY OF DISTINGUISHED MEN AND EXPERTS.

WILLIAM B. CARPENTER, M.D., F.R.S.,
Registrar to the University of London.

"If we knock out of the existing system of universally accepted physiological knowledge all that has been learned from experiment, and what experiment alone can reveal, we should go back to a depth of ignorance which must cause a most lamentable increase in human suffering, through the maltreatment of disease and injury which would be the result."—*London Athenæum*, Sept. 22, 1866.

G. COLIN, *Chief of the Service of Anatomy and Physiology at the Imperial Veterinary School at Alfort.*

"The admirable discoveries which have been made, and the precision which they have ac-

quired by this means, are enough to show the immense utility of the method of experimentation. Is there a single point in physiology which has not derived some light from this source?"—*Traité de Physiologie Comparée des Animaux Domestiques.* Paris, 1854. Tome i., p. 30.

MOQUIN-TANDON, *Member of the Institute of France; of the Parisian Society for the Protection of Animals; Professor of Natural History in the Faculty of Paris.*

"Experiments upon living animals are indispensable to physiology. The truth of this statement cannot be seriously questioned. The results which have been derived from vivisections are immense, and we appeal, in confirmation of this fact, to all physicians, to all surgeons, and to all naturalists.—*Bulletin de l'Académie Impériale de Médecine*, 1863. Tome xxviii., p. 952.

MAX PARCHAPPE, *Member of the French Academy of Medicine; Officer of the Legion of Honor; Inspector-General of Prisons and Asylums for the Insane.*

"For these reasons, I may say confidently that experimentation upon living animals is an element indispensable to the true method of study in the biological sciences."—*Bulletin de l'Académie de Médecine.* Tome xxviii., p. 1073.

JULES BÉCLARD, *Assistant Professor of Hygiene in the Faculty of Medicine, Paris.*

"It is needless in this assembly to prove that, of all the means at the disposal of physiology, experimentation upon living animals is that to which science is indebted for its greatest progress. The most important and fundamental discoveries could not have been made without it. If you are interrogating life, it is vitality alone that can give the answer"—*Bulletin de l'Académie de Médecine.* Tome xxviii., p. 1085.

F. A. Piorry, *Professor of Clinical Medicine at the Hospital of La Charité, Paris.*

"Medical practice at the present day is founded upon the known facts of physiology, as applied to pathology and clinical medicine. Now, a man must have read nothing and must know nothing, not to acknowledge at once that vivisection has been the point of departure, or at least the most positive means of discovery for the functions of the human body."—*Bulletin de l'Académie de Médecine.* Tome xxviii., p. 1096.

H. Bouley, *Member of the French Academy of Medicine; Professor at the Veterinary School at Alfort.*

"It cannot be questioned, by any one competent to judge, that vivisections constitute a means of investigation, by the aid of which physiology has been taken out of the realm of dreams and conjectures, and definitely placed upon the sure basis of observation."—*Bulletin de l'Académie de Médecine.* Tome xxviii., p. 1101.

L. Gosselin, *Professor of Clinical Surgery in the Faculty of Medicine, Paris.*

"I believe, with MM. Béclard, Bouvier, Piorry, Vernois, and Bouley, that no one can dispute the utility of vivisection, and that courses of experimental physiology should be encouraged, since they multiply the means of scientific inquiry."—*Bulletin de l'Académie de Médecine.* Tome xxviii., p. 1134.

The occasion for the remarks quoted above, from the Proceedings of the French Academy of Medicine, was a Memorial addressed in 1863 to the French government, by the London Society for the Prevention of Cruelty to Animals, complaining of the cruelties alleged to be practised in France, and asking the authorities to interfere. The matter was referred by the government to the Academy of Medicine; and the Academy, after full discussion, declared by a unanimous vote that the complaints were made without just foundation, and that it was undesirable to exercise governmental interference.

The vote is recorded in the Bulletin of the Imperial Academy of Medicine, Vol. xxviii., p. 1136.

EDWARD H. CLARKE, M.D., *Member of the Massachusetts Medical Society; Fellow of the American Academy of Arts and Sciences; late Professor of Materia Medica in the Medical Department of Harvard University.*

"The progress which has been made in therapeutics for the last quarter of a century is probably greater than has been made in twice that length of time for many centuries past. But the advance in therapeutics is largely due to experiments upon animals by physiologists. It would be difficult to estimate the amount of human suffering that will remain unrelieved if these studies cannot be carried on."

EDW. H. CLARKE, M.D.

BOSTON, *October* 4, 1874.

Austin Flint, M.D., *President of the New York Academy of Medicine; Professor of the Principles and Practice of Medicine and Clinical Medicine in the Bellevue Hospital Medical College, New York.*

"Any one who is conversant with the great advances in knowledge of physiology, during the last half century, must be aware that they have been made chiefly through the agency of vivisections and other methods of experimentation on living animals. Our knowledge of diseases is always enlarged by advances in physiology; and, moreover, experimentation with direct reference to pathology has already been of much practical value. We must look to this province of investigation for further information, in addition to that already acquired, concerning the causes of disease and the physiological effects of remedies."

Austin Flint, M.D.

New York, *November* 9, 1874.

WILLARD PARKER, M.D., *Professor of Clinical Surgery in the College of Physicians and Surgeons, New York.*

"Experimentation on animals has been of signal service in the department of Surgery. The experiments of John Hunter, Sir Charles Bell, and others, on the ligature of arteries, the regeneration of bone, artificial respiration, the transfusion of blood, the section of nerves for neuralgia, and the nature of septic inflammations, have led to important results in the treatment of surgical affections. There is no doubt that the knowledge obtained in this way has been the means of saving life and limb in many cases of injury or disease."

WILLARD PARKER, M.D.

NEW YORK, *November* 23, 1874.